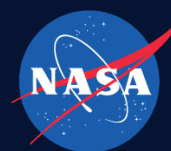


# Spacecraft Fire Safety Demonstration Project

Advanced Exploration Systems Program | Human Exploration And Operations

Mission Directorate (HEOMD)



## ABSTRACT

The objective of the Spacecraft Fire Safety Demonstration project is to conduct large-scale low-gravity fire safety experiments on an International Space Station (ISS) re-supply vehicle after it leaves the ISS. These experiments will obtain data on flammability of materials, fire detection, fire suppression, fire response, and post-fire cleanup. The data will develop a solid connection between fire safety tests conducted in normal gravity and material flammability in the long-duration low-gravity conditions that will be experienced by NASA's exploration vehicles.

By quantifying this risk through these experiments, the equipment and procedures required to respond to a spacecraft fire can be developed and incorporated into exploration vehicles. Overall, the goals of this project can be summarized as follows:

1. Design, develop, integrate, and operate three large-scale spaceflight experiments to demonstrate fire safety technologies on-orbit,
2. Provide science data on the growth rate of a large-scale fire in microgravity,
3. Evaluate material flammability limits of spacecraft materials in microgravity,
4. Develop and refine numerical models that capture large-scale solid fuel flame propagation on-orbit in microgravity, and
5. Disseminate and report the results of the on-orbit experiments and modeling efforts

## ANTICIPATED BENEFITS

### To NASA funded missions:

This project will benefit all future human exploration missions by providing data and validated models that describe the growth of large-scale spacecraft fires and the effectiveness of fire response technologies. This data, and the models that will be

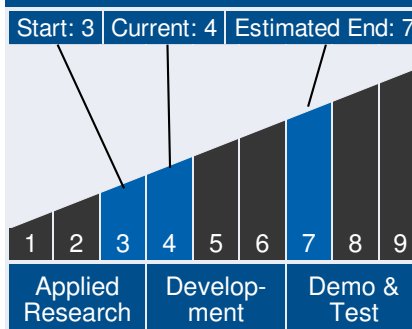


The Saffire logo shows the Cygnus vehicle in the foreground. The three bright stars to the left of the burning sapphire gem represent the three experiment units being developed.

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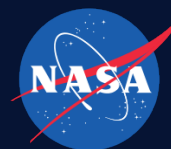
## Technology Maturity



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developed, will be used to developed effective fire safety strategies, equipment, and procedures for all crewed vehicles used on exploration missions.

## To NASA unfunded & planned missions:

Experimental results from the missions will provide data on material flammability in low-g standard and elevated oxygen atmospheres, provide validated numerical models that can be applied during the design of planned spacecraft to provide effective fire detection and response protocols, and provide post-fire monitoring and response equipment that has been demonstrated to be effective on spacecraft in low-g.

## To other government agencies:

Experimental results from the mission will provide data on material flammability which will improve mission safety for applications such as piloted aircraft with high oxygen concentration environments. The fire detection and monitoring technologies could also be applied to other flight applications where the measurement of specific gaseous species is required.

## To the commercial space industry:

Understanding low-gravity material flammability will benefit both NASA and commercial space industry in selecting and deploying new materials in human space missions. Also, the results will be used by regulatory agencies to help develop fire safety standards for commercial space industry partners that intend to operate crewed space vehicles. These standards will define the fire protection capability that must be designed into their systems.

## To the nation:

Understanding low-gravity material flammability and having relevant data on the behavior of and response to fires on spacecraft will benefit both NASA and commercial space industry in both the selection of materials and development of fire safety strategies for the specific vehicles and missions. Also, the results will be used by regulatory agencies to help develop



1 Conference Paper  
1 Publication

## Management Team

### Program Director:

- Jason Crusan

### Program Executive:

- Jitendra Joshi

### Project Manager:

- Gary Ruff

### Principal Investigator:

- David Urban

## Technology Areas

### Primary Technology Area:

Human Health, Life Support, and Habitation Systems (TA 6)  
Human Health, Life Support, and Habitation Systems (TA 6)

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fire safety standards for commercial space industry partners that intend to operation crewed space vehicles. These standards will define the fire protections capability that must be designed into their systems.

## DETAILED DESCRIPTION

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The objective of the Spacecraft Fire Safety Demonstration project is to develop and conduct large-scale fire safety experiments on an International Space Station resupply vehicle after it leaves the ISS and before it re-enters the Earth's atmosphere. Three Spacecraft Fire Experiment (*Saffire*) flight units have been developed and will fly on three sequential flights of Orbital ATK's Cygnus re-supply vehicle beginning in March 2016 through October 2016. The SFS Demo Project is managed by NASA John H. Glenn Research Center (GRC) who also developed the design and fabricated the hardware. Personnel from NASA Johnson Spaceflight Center and the NASA White Sands Test Facility were also instrumental in fabricating and testing the *Saffire* hardware. The NASA team is augmented by an international topical team assembled by the European Space Agency (ESA). Each member of this team brings expertise and funding from their respective space and research agencies for their activities.

The experiment hardware is approximately 53 cm x 90 cm x 133 cm and consists of a flow duct, containing the sample material to be burned, fans, and flow straightener, and an avionics bay, containing the power management system, control computer, signal conditioning card, and cameras. *Saffire*-I and III have a single large sample (0.4 m x 0.9 m) made of a composite fabric (75% cotton/25% fiberglass by mass) that has been studied in previous low-gravity experiments although using much smaller samples. This sample is expected to burn completely during these tests and will yield information about the fate (flame size and spread rate) of a large-scale fire in low-gravity. *Saffire*-II has nine samples (5-cm wide x 30-cm long) of various materials that were selected to investigate the low-gravity Maximum Oxygen Concentration (MOC) flammability limits in long-term low gravity. These samples emulate the configuration used in NASA-STD-6001 Test 1, the flammability test conducted in normal gravity to determine if a flame will spread upward over the sample or if it will self-extinguish. A material that self-extinguishes is considered as being safe for use in spacecraft from the standpoint of flammability.

*Saffire* will be loaded in the Cygnus Pressurized Cargo Module by Orbital ATK and launched from the Wallops Flight Facility. Once at the International Space Station, *Saffire* will remain unpowered on Cygnus while supplies for the ISS are off-loaded by the crew. Once supplies are off-loaded and replaced with trash, Cygnus will depart. When the vehicle reaches a safe distance from the ISS, Cygnus will be powered on by a team of Orbital ATK and *Saffire* engineers working from Orbital ATK's Dulles Control Center in Dulles, VA. After conducting system checks, Cygnus will be put into

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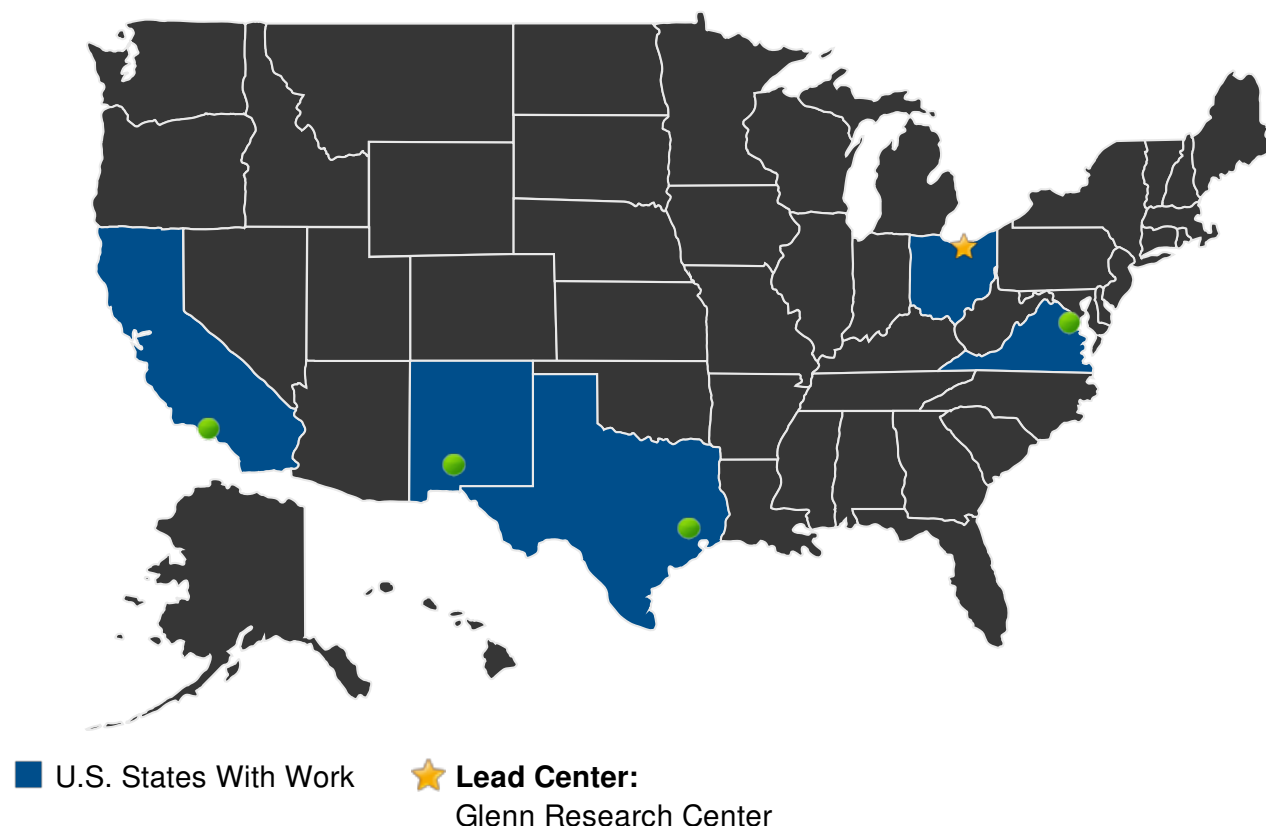
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free drift and the experiment will be initiated and run autonomously for about 2-1/2 hours. When the experiment is complete, Cygnus will continue to orbit the earth while the data is downlinked to various ground stations. When downlink is complete, Cygnus will then begin its reentry into the Earth's atmosphere where it will burn-up over the Pacific Ocean.

While Saffire-I, II, and III are being readied for operation, the Spacecraft Fire Safety Demonstration team is preparing for another three Saffire flights that will continue to investigate material flammability risks that will be faced by the crew on NASA's long duration exploration missions. These next three experiments will also evaluate the performance of fire response equipment to be used by these crews as well as obtain valuable data to allow spacecraft designers and engineers to predict the development of fire scenarios in exploration vehicles and habitats.

### U.S. WORK LOCATIONS AND KEY PARTNERS



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## ● Supporting Centers:

- Jet Propulsion Laboratory
- Johnson Space Center
- NASA Headquarters
- White Sands Test Facility

## Other Organizations Performing Work:

- Case Western Reserve University
- Orbital ATK Space Systems Group (Dulles, VA)
- TDA Research, Inc. (Wheat Ridge, CO)
- University of California at Berkeley
- Vista Photonics, Inc. (Santa Fe, NM)

## Contributing Partners:

- European Space Agency

## PROJECT LIBRARY

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### Conference Papers

- Development of Large-Scale Spacecraft Fire Safety Experiments
  - (<http://techport.nasa.gov:80/file/2962>)

### Publications

- Success Story: Development of the Spacecraft Fire Experiment (Saffire)
  - (<http://techport.nasa.gov:80/file/26160>)

## DETAILS FOR TECHNOLOGY 1

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### Technology Title

Combustion Product Monitor

### Technology Description

This technology is categorized as a hardware subsystem for manned spaceflight

This technology is used on-orbit following a fire detector alarm to confirm or refute the presence of a fire event. If confirmed, this technology will monitor the atmosphere during the fire event and

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subsequent clean up to assess when the atmosphere is safe for the crew to continue operations.

### Capabilities Provided

This technology will monitor not only O<sub>2</sub>, CO<sub>2</sub>, and CO but combustion products typically produced from spacecraft materials including HF, HCl, and HCN.

### Potential Applications

The Combustion Product Monitor will serve as a real-time monitor for fire events and enhance crew safety and health.

### Performance Metrics

| Metric  | Unit | Quantity |
|---|------|----------|
| Detection of combustion products at ppm level |      |          |